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## Appendix A

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### Experimental Protocol

Verbal instructions are in **boldface** type. Procedural instructions in plain type. Following each protocol is an example of the corresponding examination.

Notes:

Each subject is required to read and sign a consent form.

Each subject is given a standard color blindness exam.

### Cognitive Factors Examination Instructions

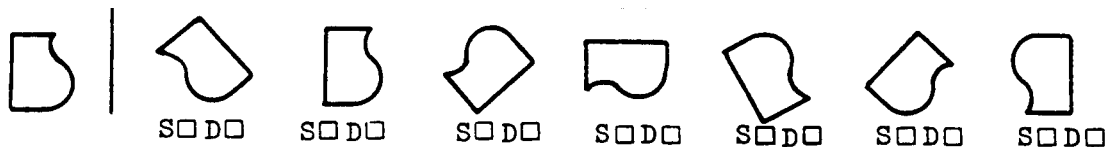
**The following examinations are not an intelligence test of any kind. They are intended to evaluate a number of natural human abilities which we will investigate further in the second part of the experiment. The answers you give as well as your test scores are confidential and will be known only to me for the purposes of this experiment.**

For each exam, first read the instruction page(s), answer any procedural questions, and begin.

#### Spatial Orientation (S):

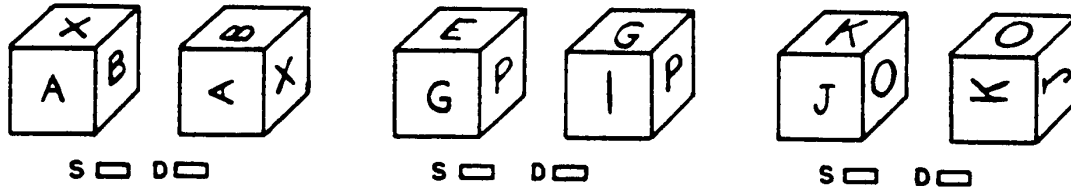
##### Card Rotations Test — S-1

Each item gives a drawing of a card cut into an irregular shape. To its right are seven other drawings of the same card, sometimes merely rotated and sometimes turned over to its other side. The subject indicates whether or not the card has been turned over.



## Cube Comparisons Test — S-2

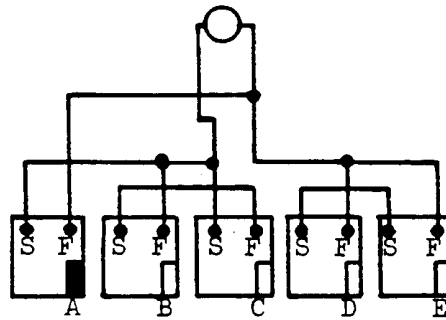
Each item presents two drawings of a cube. Assuming no cube can have two faces alike, the subject is to indicate which items present drawings that can be of the same cube and which present drawings that cannot be of the same cube.



## Spatial Scanning (SS):

## Choosing a Path — SS-2

Each item consists of a network of lines (as in an electrical circuit diagram) having many intersecting and intermeshed wires with several sets of terminals. The task is to trace the lines and to determine for which one of 5 pairs of terminals, marked S (start) and F (finish), there is a complete circuit through a circle at the top. There is some orderliness in the layout to encourage comprehension of the pattern by scanning rather than simple visual pursuit of lines.



## Map Planning Test — SS-3

The examinee sees diagrammatic sections representing city maps. The streets are blocked at various points by barriers represented by circles. The examinee must plan routes between given points in such a way that no road-blocks need to be crossed. The task is to find the shortest available route as quickly as possible.

										The shortest route from:	Passes building:
										1. A to Z	<u>1</u>
										2. E to S	<u>          </u>
										3. P to J	<u>          </u>
										4. V to K	<u>          </u>
										5. O to F	<u>          </u>
										6. G to M	<u>          </u>
										7. D to Q	<u>          </u>
										8. F to T	<u>          </u>

**Visualization (VZ):**

Form Board Test — VZ-1

Each item presents five shaded drawings of pieces, some or all of which can be put together to form a figure presented in outline form. The task is to indicate which of the pieces, when fitted together, would form the outline.

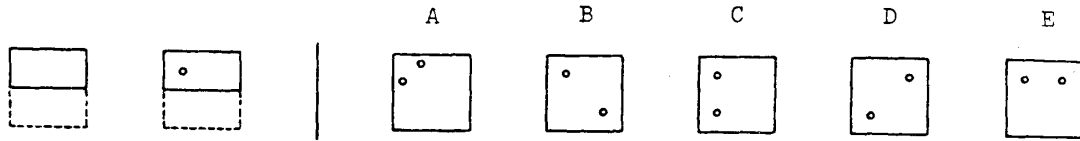
A.

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

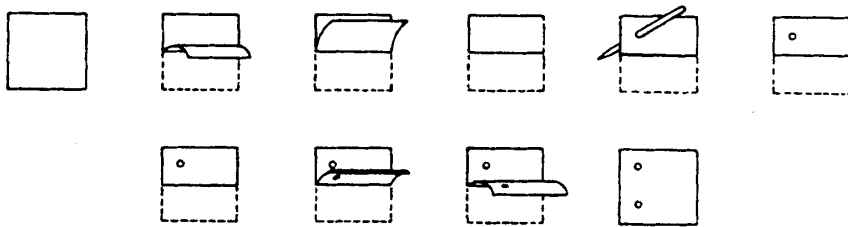
Answer

Paper Folding Test — VZ-2

For each item successive drawings illustrate two or three folds made in a square sheet of paper. The final drawing of the folded paper shows where a hole is punched in it. The subject selects one of five drawings to show how the punched sheet would appear when fully reopened.



The correct answer to the sample problem above is C and so it should have been marked with an X. The figures below show how the paper was folded and why C is the correct answer.



## Embedded Figures Test Instructions

(From Witkin, 1971)

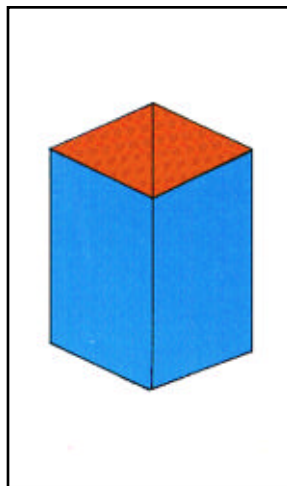
**I am going to show you a series of colored designs. I will then show you a simple form which is contained in that larger design. You will then be given the larger design again, and your job will be to locate the simple form in it. Let's go through a practice trial to show you how it is done.**

Show sample complex figure P-X for 15 seconds, then simple form P for 10 seconds.

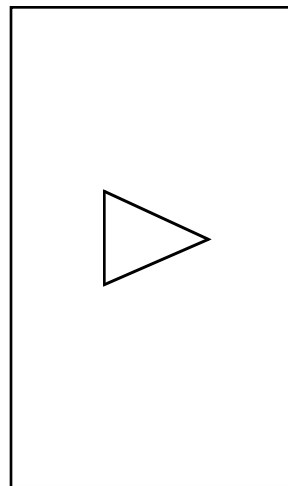
**I will now show you the colored design again and you are to find the simple form in it. As soon as you have found the simple form let me know, and start tracing the simple form with this stylus.**

Show sample complex form P-X for a maximum time of 3 minutes.

**This is how we will proceed on all trials. In every case the simple form will be present in the larger design. It will always be in the upright position, so don't turn the card around. There may be several of the simple forms in the same design, but you are to find and trace only one. Work as quickly as you possibly can, since I will be timing you, but be sure that the form you find is exactly the same as the original simple form in shape, size and proportions. As soon as you have found the form, tell me at once and then start to trace it. If you ever forget what the simple form looks like, you may ask to see it again, and you may do so as often as you like. Are there any questions?**



**P-X**



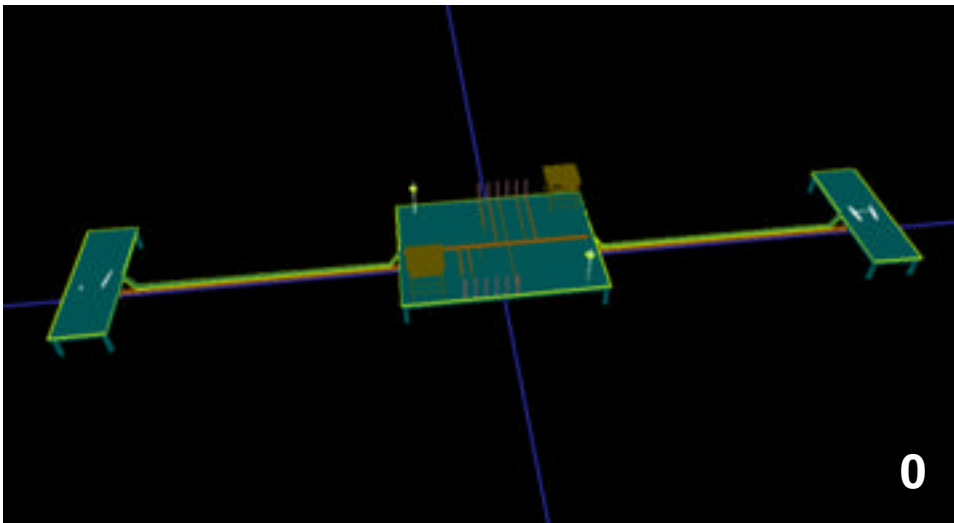
**P**

### Virtual Environment Wayfinding Instructions

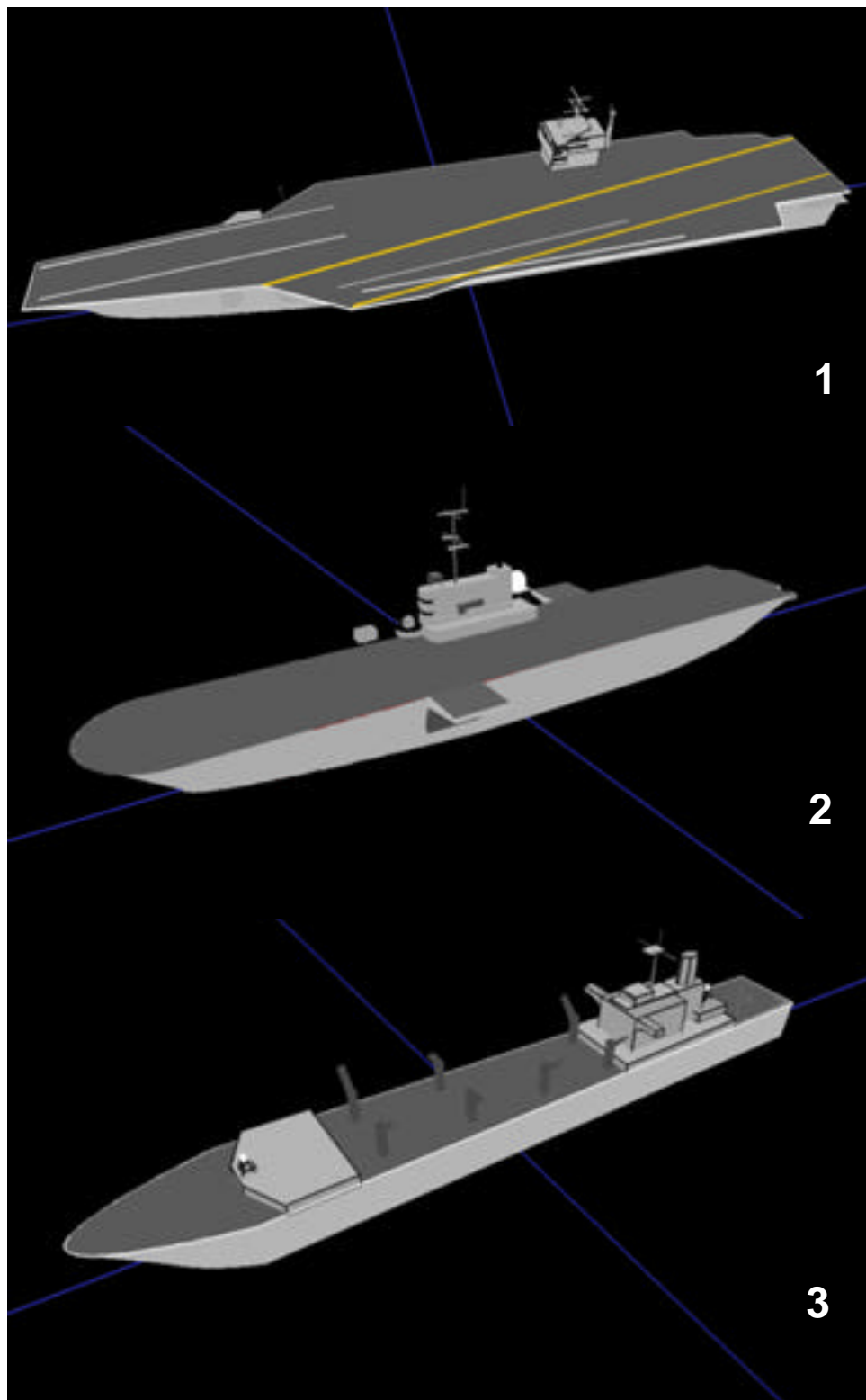
Each of the following virtual worlds contain open sea and land masses. The worlds are very large. Below is an example world. It will not be used in this experiment.

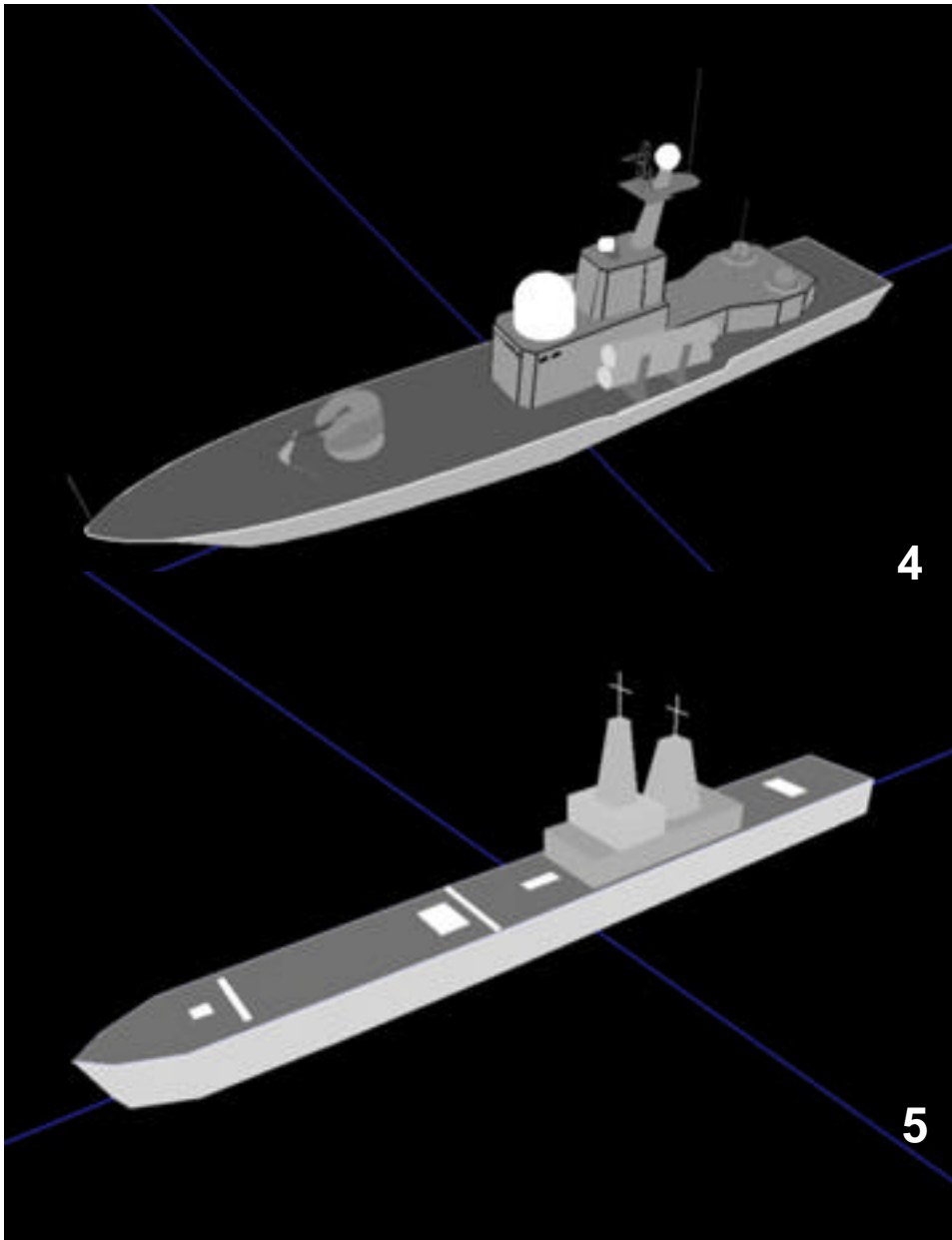


You will always begin on this platform labeled #0.



Remember what it looks like as you will be required to return to it at the conclusion of each trial. When instructed to do so, begin searching the world for the following five targets. Each is labeled 1-5 for easy identification. All targets will be present in all worlds. The number assigned to each will remain constant in all trials. However, there is no need to memorize the numbers.





**You may search for the targets in any order you wish. The targets may be anywhere in the environment but will always be on the ocean surface — never on a land mass. As you locate each target, move towards it until I instruct you to continue searching for another target or to return home.**

**Your movement is controlled with the joystick and button on the BOOM. The joystick acts as an accelerator. Push up to thrust forward, pull down to thrust back-**

ward, push the red button to stop, or do nothing to continue. (Demonstrate.) You will always move in the direction you are currently looking. You may also move backwards if you wish. Your movement is constrained vertically so that you cannot move below the ocean surface nor above a set maximum altitude. Movement is also constrained horizontally to a square. If you reach the edge of the world, you will hear an audible signal (Demonstrate.) and your movement will stop.

Your objective is to locate all five targets as quickly as possible and then return directly to the home target. While you are searching, I want you to *think aloud* describing what you are doing and thinking. At the conclusion of each trial, you will be asked to sketch a map of the environment in as much detail as you can.

You may ask to rest in between trials but not once a trial has begun. Let's get started with a sample world so that you can better understand the tasks.

## Wayfinding in Virtual Worlds Experiment

### CONSENT FORM

With data from you and other participants we hope to find out more about how people navigate large virtual spaces, how virtual world navigation differs from real-world navigation, and how we can help alleviate navigation problems. Please read and sign this form indicating that you agree to be in the study. Ask any questions you may have before signing.

**Background information:** This study is being performed as part of the dissertation research of Rudy Darken, Code 5707.

**Procedures:** If you decide to participate in this study, the experimenter will explain the tasks in detail. There will be two, 1-hour sessions. The first session involves a number of pencil-and-paper tests. The second session involves the execution of searching tasks in a number of virtual worlds.

**Risks and benefits of being in the study:** This study has no risks. The benefits to participants are that they gain experience with novel interaction devices and contribute to current research in human-computer interaction.

**Compensation:** A copy of the results will be available to you at the conclusion of the experiment.

**Confidentiality:** The records of this study will be kept private. In any report we might publish, we will not include any information that might make it possible to identify you as a participant. Research records will be kept in a locked file. Only the researcher will have access to the records.

**Voluntary nature of the study:** If you decide to participate, you are free to withdraw at any time without prejudice.

**Contact and questions:** The researcher involved in this study is Rudy Darken (bldg. 210, rm. 3404, 767-6814). You may ask any questions you have now. If you agree to participate, please schedule a date and time.

**You will be given a copy of this form for your records.**

**Statement of consent:** I have read the above information. I have asked questions and have had my questions answered. I consent to participate in the study.

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Signature

Date

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Signature of Investigator

Date

## Protocol: Wayfinding in Large-Scale Virtual Spaces

**Objective:** Wayfinding problems exist in all large-scale virtual spaces. Unfortunately, the design of virtual world applications has not yet incorporated any type of methodology to solve these problems. Furthermore, there are no well-defined principles of human spatial organization which have been shown to hold for virtual spaces. The purpose of this experiment is to show that real-world wayfinding principles can be adapted for use in virtual spaces and that the adherence to these principles results in environments which are more easily navigable than those which violate the principles.

**Method:** A subject will be asked to perform a navigation task in each of four virtual worlds. A training period will be used on a sample world to introduce subjects to the apparatus and procedural methods of the experiment. All trials will be video and audio taped. A verbal protocol will be used. Search times and position/orientation tracks will be sampled throughout each trial. A map sketching exercise will conclude each trial.

**Means:** The experiment will be run on a Silicon Graphics Onyx RE workstation configured with a Fakespace BOOM3C head-coupled display/tracker. A subject will stand, placing the eyes into the display held by either hand.

**Risks:** This research involves no risks or discomforts greater than those encountered in daily life. The room in which the experiment will be held conforms with NRL Safety and Occupational Health Manual, NRLINST 5100.13B.

**Safety Measures:** The experimenter will be present continuously and will monitor the safety of the procedure. In the unlikely event of a medical emergency or natural disaster, the experiment will be stopped immediately. On site Fire (767-3333) and Ambulance (767-2222) services will be called as appropriate.

**Subjects:** Ten volunteers (5 male and 5 female) will be recruited as subjects who will participate for two approximately one-hour sessions. Participants are free to withdraw at any time. The benefits to participants are that they gain experience with novel interaction devices and contribute to current research in human-computer interaction. No tangible reward will be given. A copy of the results will be made available at the conclusion of the experiment.

**Confidentiality:** The data collected will not be linked with the name of the subject in any way. Each subject will be assigned a number from a list of random numbers and that number will be the only identification used to index the results.

**Consent:** Subjects will be asked to sign a consent form before the start of the experiment. Subjects will be given the names and telephone number of the experimenter so that they are able to voice any concerns at any time.

